角马蜂贮精囊及精子的形态学观察

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摘要：昆虫贮精囊和精子的形态多样性是重要的分类和系统发育分析特征之一，然而在马蜂亚科乃至整个胡蜂科中却鲜有涉及。本文首次解剖了角马蜂 *Polistes chinensis antennalis* Pérez 的雄性生殖系统，着重对其贮精囊的超微结构进行描述，并简要报道了精子的外部形态。角马蜂的贮精囊由输精管亚前端膨大而成，有一层发达的柱状上皮细胞贴在基底膜内壁：细胞核位于柱状细胞基部，上皮细胞端半部线粒体密集，顶膜特化成微绒毛。角马蜂精子头长 21.4 μm，体长 94 μm，是已报道胡蜂科精子中长度最短、相对头长最长的种类。研究结果为胡蜂科昆虫系统发育以及繁殖生理提供理论依据。

关键词：马蜂亚科；角马蜂；雄性生殖系统；贮精囊；精子；超微结构；透射电镜
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Morphology of seminal vesicle and sperm of the male *Polistes chinensis antennalis* (Hymenoptera: Vespidae)

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Abstract: Morphological diversity of seminal vesicles and spermatozoa play an important role in the taxonomic and phylogenetic analysis, but it has been scarcely studied in the subfamily Polistinae, even in the whole Vespidae. The male reproductive system of the paper wasp *Polistes chinensis antennalis* Pérez was dissected for the first time, with emphasis on the ultrastructure of the seminal vesicle. The morphology of the sperm was also briefly reported. Seminal vesicle and accessory gland are not surrounded by a common sheath. The epithelium of seminal vesicle consists of a monolayer of cubical cells, adhering to a thick basal lamina, and these epithelial cells are polarized: the apical half of the epithelial cells is especially rich in mitochondria with the apical membrane being differentiated into microvilli, while the basal half contains the usual cellular organelles, including some mitochondria, the nucleus and prominent inclusions. The spermatozoa of *P. chinensis antennalis* are about 94 μm in length with the head about 21.4 μm in length, so it is the species with the shortest sperm and the longest relative head length of sperm described for the family Vespidae. The results may provide a theoretical foundation for phylogenetic analysis and reproductive physiology of Vespidae.

Key words: Polistinae; *Polistes chinensis antennalis*; male reproductive system; seminal vesicle; sperm; ultrastructure; transmission electron microscopy (TEM)

昆虫雄性生殖系统通常包括成对的精巢和输精管，输精管并入射精管，射精管末端为射精孔；贮精囊(seminal vesicle)通常由输精管的一部分扩大形成，是精子的暂存器官，起源于中胚层(Snodgrass, 1935)。作为重要的分类和系统发育分析特征之一，昆虫雄性生殖系统的形态在许多类群都有研究，然而在马蜂亚科乃至整个胡蜂科中却鲜有涉及：Bordas (1895)首次描述了主要分布在欧洲的高卢马蜂 *Polistes gallicus* (L.)的雄性生殖系统，Dirks 和 Sternburg (1972)及 Araújo 等(2010)分别对北美的 4 种马蜂，即：格马蜂 *Polistes metricus* Say，喧马蜂 *P. exclamans* Viereck，环马蜂 *P.*

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表 1 胡蜂科精子总长、头长以及相对头长

Table 1 Total length, head (acrosome and nucleus) length and relative head length for the sperm of Vespidae

亚科 Subfamily	种名 Species	标本产地 Origin	总长(μm) Total length	头长(μm) Head length	头长/总长 Head/total length	参考文献 References
马蜂亚科 Polistinae	马蜂 *Polistes* sp.	阿根廷 Argentina	117	–	–	Quicke *et al*. (1992)
	多色马蜂 *P. versicolor versicolor*	美国 U. S. A.	110	17	0.15	Araújo *et al*. (2010)
	角马蜂 *P. chinensis antennalis*	中国 China	94	21.4	0.23	
	近光胡蜂 *Agelaia vicina*	巴西 Brazil	218	21	0.10	Mancini *et al*. (2006)
	美胡蜂 *Myschocyttarus* sp.	阿根廷 Argentina	244	–	–	Quicke *et al*. (1992)
	卡美胡蜂 *M. cassununga*	巴西 Brazil	97	14	0.14	Moreira *et al*. (2012)
胡蜂亚科 Vespinae	常见黄胡蜂 *Vespula vulgaris*	英国 U. K.	129	–	–	Quicke *et al*. (1992)
蜾蠃亚科 Eumeninae	友蜾蠃 *Eumenes fraternus*	加拿大 Canada	577	19	0.03	Quicke *et al*. (1992)
	安沟蜾蠃 *Ancistrocerus antilope*	美国 U. S. A.	388	12.3	0.03	Bushrow *et al*. (2006)

表中数值为平均值；除角马蜂外，其他种类的相关数据均摘自相应文献。Data in the table are means; data regarding species other than *P. chinensis antennalis* were summarized from references.

本研究首次从超微水平上揭示了角马蜂 *P. chinensis antennalis* 的贮精囊结构。从发达的微绒毛和分泌囊泡来看，上皮细胞明显具有腺细胞的特征；与 Araújo 等(2005)无刺蜂 *Scaptotrigona xanthotricha* 贮精囊的结构类比，相同之处在于：(1)由外向内组织分层次序一致；(2)上皮细胞呈极性，端部线粒体密集，顶膜特化成微绒毛；(3)上皮细胞膜可见半桥粒状锚接点和发达的纵隔结；(4)细胞内有含不同内含物的内含体。主要不同点：(1)外膜多层、厚且疏松，而肌肉层薄，仅 1 层(而无刺蜂 *S. xanthotricha* 外膜仅 1 层，细胞间连接紧密，肌肉层厚，肌原纤维多层)；(2)上皮细胞基部至中部无大型分泌囊泡(而 *S. xanthotricha* 含多个大型囊泡充满细胞的基半部)；(3)上皮细胞内未观察到精子束或团的夹入(而 *S. xanthotricha* 的上皮细胞内检视到了精子束包囊)。这些特征在分类和系统发育中的意义尚待进一步探讨。

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